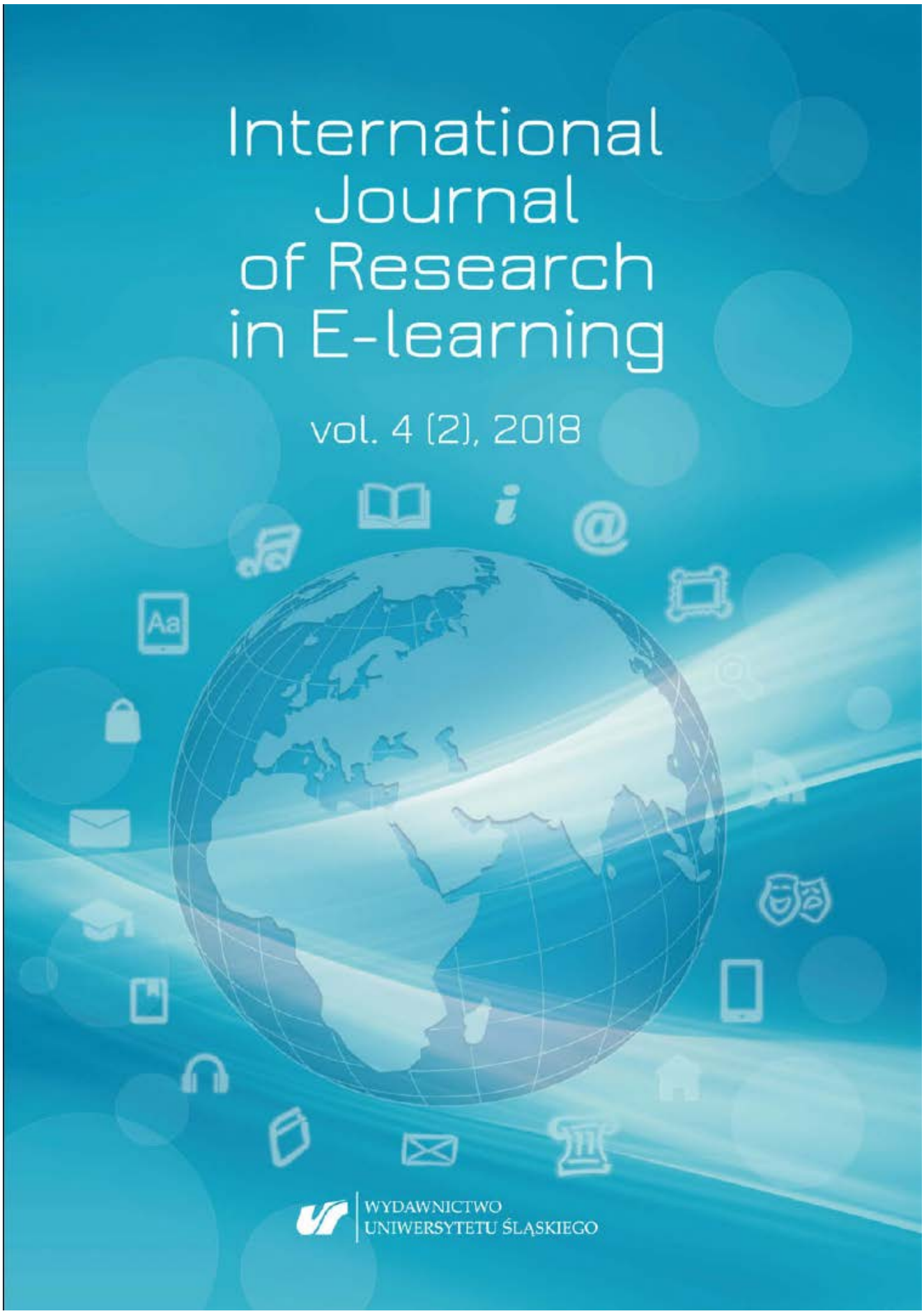
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Contents

International Journal of Research in E-learning
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Editorial

In this volume of the *International Journal of Research in E-learning*, authors from different countries are trying to answer the following question: what should be the university / school of the 21st century? Among other things, it should be open to innovation – not only in the world of technology, but also in relation to teaching and learning processes. Personalisation of teaching / learning should take place – a student is in the centre of the university / school of the 21st century. Another desirable feature is highly qualified staff, open and prepared for lifelong learning. One of the pillars of preparing new generation specialists should be STEM education, internationalisation of higher education, and mobility.

The present volume includes seven articles gathered in three chapters.

Chapter I – "Evolution of Innovative Educational Environment and Development of Digital STEM Competences" – includes four articles. At the beginning of this chapter, Nataliia Morze, Oksana Strutynska, and Mariia Umryk – Ukrainian experienced authors – present the article "Implementation of Robotics as a Modern Trend in STEM Education." They state that the world revolves around innovations: new ideas, new products, new solutions to existing problems. Science, technology, engineering, and mathematics are the foundation for innovation. The development of STEM-directions in education is crucial for the development of modern society. The paper discusses implementation of STEM education in the learning process of educational institutions. The authors analyse the development of STEM education in Ukraine, determine the level of readiness of educators for understanding the principles of STEM education, and substantiate the need for introducing robotics into the educational process as a modern and important trend in STEM education. The concept of educational robotics is discussed. This makes it possible to identify the technical inclinations of students (at an early stage) and development of these inclinations, as well as formation of STEM competency in general. The study focuses on the interdisciplinary aspect of STEM education, in particular on the implementation of interdisciplinary links between STEM subjects and robotics in the conduction process of research and training projects. The authors provide examples of the implementation of robotics in the educational process based on the use of a project method. The article also delineates the project for the creation of the Juno Rover robot based on the Arduino robotic platform in

university education and gives two examples of the robotics projects in school education; one of them is implemented on an open platform with freely distributed materials for creating and using 3D printed robots. The second manuscript – "Applying QR Codes in Facilitating Mathematics and Informatics Education" – has been elaborated by Slovak researchers Lilla Koreňová and Jozef Hvorecký. They stress that QR codes are usually discussed in the context of mobile learning. In their presentation, the authors show other opportunities of their use with special focus on mathematics and informatics education and its methodology. Appropriately placed QR codes can, for example, be applied to create a feedback for both students and teachers, as an additional source of problems in a problem solver or a worksheet, or as an input gate to a didactic game. The addressees use their smartphones to read their selected QR code. The code refers to a file containing the data files predesigned and stored by their educator or the author of learning materials. The data are then used in accordance with their educator's instruction. Similarly, a QR code can link additional information sources in a worksheet or open the student's gate to the course/instructor evaluation. In the paper, such an approach is portrayed using examples from various fields of mathematics, statistics, and databases. Finally, the authors discuss advantages and disadvantages of this approach. The third article, "Influence of University Innovative Educational Environment on the Development of Digital STEM Competences" has been prepared by researchers from Ukraine – Nadiia Balyk, Galina Shmyger, and Yaroslav Vasylenko. The article deals with the problem of the influence of the innovative educational environment of the university on the development of digital STEM competences in the process of training teachers of the new formation. It is determined that the innovative educational environment of the university consists of organisational, educational, methodological, and technological and information resources, the purpose of which is to create conditions for the development of digital STEM competences of teachers. The main aspects of introduction and development of STEM education in different countries of the world are analysed. Particular attention is paid to the functioning of the STEM Centre, which is the basis of the innovative educational environment of the pedagogical university. The practical experience in introduction of STEM education at Ternopil Volodymyr Hnatiuk National Pedagogical University is summarised. The peculiarities of the influence of the innovative educational environment of the university on the development of digital STEM competences are explored. The last article in the chapter, "MDB as an Effective Platform of Communication between Students and Teachers: A Study of the Virtual University of Pakistan," has been prepared by Pakistani researchers Nadia Saleem, Aisha M Din, Saba Sadiq, and Masroor Ahmed. They stress that the integration of distance learning and Information Communication technology has brought a lot of convenience for the students who were earlier facing problems in education due to time and geographical limitations. Since the concept of e-learning is comparatively new and different, the discourse on teaching methodologies and

the student–teacher relationship in an e-learning environment has brought many new dimensions under discussion. In a virtual system, the communication bonding between a student and a teacher is not so strong. Students are dependent on one-way communication in the form of recorded lectures, published announcements, and information given on a website. Bridging the communication gap between a student and a teacher through MDB (Moderate Discussion Board) is an effective step taken by the Virtual University of Pakistan in online education to address students. This research was aimed at investigating the effectiveness of MDB as an interaction platform between students and course instructors at the Virtual University of Pakistan. The effectiveness of MDBs was measured through analysing the number of MDBs posted in a certain course and the nature of questions asked in MDBs by students. It was a quantitative study in which two Mass Communication subjects were selected through purposive sampling. The collected data were analysed in percentages, and a statistical test Correlation was applied to find out if there was some relation between the strength of students and questions asked through MDB. The study found that although the number of MDBs is quite lower than that of enrolled students, it is an effective platform of communication between students and a teacher, as students can ask questions related to subject, exams, semester activities, and general concerns.

Chapter II – "Innovative Models, Methods, and Means in Electronical Education" – contains two articles. The authors of the first article, "The Multimedia Presentation of a Lecture as the Means of Perception, Comprehension, and Memorisation of Educational Information by Students," are Svetlana Skvortsova and Maryna Haran from Ukraine. In their manuscript, the demand for teachers of Ukrainian universities to create multimedia presentations of lectures and their use in the process of teaching the course "Methodology of teaching mathematics" has been formulated as the result of the experimental research. Taking into account the specificity of the discipline and the peculiarities of the perception, comprehension, and memorisation of educational information by students, what has been determined are the requirements for visual and audio content, for the text presented on presentation slides, and for the design and navigation, and their effectiveness has been experimentally proved. In particular, it has been established that, in order to facilitate students' perception of educational information, presentation slides should not contain large text arrays. Text slices of presentations should be executed using a certain font, with a certain font size and dominant colours of the headings and main text. To facilitate understanding and memorisation of the content of teaching, the theoretical information should be structured and presented in the form of circuits, tables, diagrams, etc. To stimulate interest in learning, a positive emotional background should be created, and thus a presentation should contain bright colour objects, photographs, and video footage of real mathematics lessons. It is emphasised that, in order to create conditions for the perception, understanding, and memorisation of educational information, presentation design

should provide a single style of design and identical compositions of components; for example, image of the same type of information should be in the form of identical elements of "SmartArt." The second article, "The Role of Ecological Education and IT Education in Promoting Sustainable Development of a Human Being," has been elaborated by Natalia Maria Ruman from Poland. She argues that we live in times dominated by the media, which have an impact on virtually every sphere of our lives. Nowadays, it is difficult to imagine school education without the use of modern technologies such as computers or the Internet. In the context of the ecological crisis and a number of threats associated with it which are brought by contemporary civilisation – including those of conformism or materialism – it is necessary to present a series of actions taken in education to help children and their parents oppose contemporary threats. The Internet today is becoming a good tool for exploiting information. Ruman's article contains theoretical considerations on the important problems of modern civilisation and human education, namely issues related to ecology, the use of modern technologies, and communication. It focuses the reader's attention on important values in education for sustainable development.

Chapter III – "Reports" – contains the paper "A Report from the International Scientific Conference DLCC2018, 15–16 October 2018, Poland" elaborated by Eugenia Smyrnova-Trybulska, devoted to the 10th edition of the International Scientific Conference *DLCC2018: Theoretical and Practical Aspects of Distance Learning* (www.dlcc.us.edu.pl). The conference was held under the theme "E-learning and smart learning environment for preparing the specialists of new generation" and included reports from the IRNet project. The conference was held on 15–16 October 2018 in Wisła. It was organised by the Faculty of Ethnology and Educational Science at the University of Silesia in Cieszyn with cooperation of ten other universities and organisations. More than 90 researchers from 10 countries and from more than 20 universities participated in this conference. It is worth noting that the conference favours exchange of experiences, strengthening international cooperation, common problem solving, implementing innovative methodologies, and creating global educational space. During the conference numerous themes were discussed, such as: further directions in international cooperation, new common scientific and didactic projects, internationalisation development in the conditions of digitalisation and globalisation. More information concerning the event can be found on the website www.dlcc.us.edu.pl.

Eugenia Smyrnova-Trybulska

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Evolution of Education, and Internationalisation of Education and Competences

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Influence of University Innovative Educational Environment on the Development of Digital STEM Competences

Abstract

The article deals with the problem of the influence of the innovative educational environment of the university on the development of digital STEM competences in the process of training teachers of the new formation. It is determined that the innovative educational environment of the university consists of organisational, educational, methodological, and technological and information resources, the purpose of which is to create conditions for the development of digital STEM competences of teachers. The main aspects of introduction and development of STEM education in different countries of the world are analysed. Particular attention is paid to the functioning of the STEM Centre, which is the basis of the innovative educational environment of the pedagogical university. The practical experience in introduction of STEM education at Ternopil Volodymyr Hnatiuk National Pedagogical University is summarised. The peculiarities of the influence of the innovative educational environment of the university on the development of digital STEM competences are explored.

K e y w o r d s: STEM education, digital STEM competences, innovative educational environment, project-based learning, research

Introduction

Many countries in the world, including developed economies such as those of the United States and the European Union (EU), transform their education systems in order to be competitive in the age of innovation (Schleigh, Bossé, & Lee, 2011; Williams, 2011). Innovation is largely dependent on advances in science, technology, engineering, and mathematics. More and more jobs in all sectors of the economy require STEM knowledge, which goes beyond training for specific jobs. STEM education is aimed at developing deep mathematical and scientific knowledge, as well as developing a way of thinking and reasoning. STEM education promotes the development of creative skills and critical thinking that young people can use in all areas of their lives (Morze, Smyrnova-Trybulska, Kommers, Gladun, & Zuziak, 2017).

Ukrainian students should also be competitive on the labour market of the 21st century. Reforms taking place in the sphere of education of Ukraine contribute to this. The implementation and development of STEM education is especially important today. Within the framework of STEM education, interdisciplinary curricula are introduced, students' knowledge of STEM subjects and STEM professions increases, STEM courses are provided for students, and students are trained for successful post-school employment and education. At the same time, at each stage, this system develops students' ability to do research, work analytically, experiment, and think critically; it combines school and out-of-school opportunities and teaching methods (LaForce, Noble, King, Century, Blackwell, Holt, Ibrahim, & Loo, 2016).

The analysis of pedagogical literature shows the interest of scientists in various aspects of STEM education. Taking into account that STEM education is one of the most important directions of reforming Ukrainian education, it is worth highlighting some aspects of its implementation in the educational process.

Integrative STEM Education

In the scientific literature, researchers (Sarıer, 2010; Schleigh, Bossé, & Lee, 2011) distinguish five aspects of STEM education.

1. STEM education is focusing on challenges and problems. At STEM lessons, students are faced with real social, economic, and environmental issues and seek solutions.
2. STEM lessons focus on the engineering design process. STEM education provides a flexible design process. In this process, students determine the

problem, conduct preliminary research, put forward a few ideas for their solutions, develop and create a prototype, and then test it, evaluate it, and implement it. STEM lessons provide student teams with opportunities to conduct their research based on their own ideas, test different approaches, make mistakes, discuss them and learn from them, and carry out further research. Their focus is on finding solutions.

3. STEM education immerses students in a practical inquiry and open study. The students' work is practical and collective, and their decisions are coordinated. Students communicate, exchange ideas, and, if necessary, upgrade their prototypes. They control their own ideas and conduct their own research.
4. STEM education involves students in productive collaborative work. They need help from teachers to work together as a productive team. This becomes possible if all the teachers at school work together and meet students' expectations.
5. STEM education integrates math and science. It is necessary to create plans for joint work of teachers of various subjects. Using knowledge from various subjects during lessons will teach students to understand that combining mathematics and other sciences can solve important life problems. This will increase interest in mathematics and science. The art teacher should be drawn to such lessons as well, since art plays an important role in the development of a practice-oriented project, enhancing its attractiveness, design, and demand.

In order to integrate mathematics and science, M. Sencer Corlu, Robert M. Capraro, and Mary M. Capraro (2014) suggested the STEM education model. According to it, for the successful transition from the traditional to the integrated model of education, emphasis is placed on the importance of integrated study of disciplines and on the interaction between teachers and students. This model involves a systematic approach to the study of natural and mathematical disciplines, and promotes the development of innovation, the implementation of creative potential of the individual, and its pre-professional education.

A prominent place in this model belongs to a well-educated and experienced teacher with strong skills to interact with other subject teachers, students, and parents. Such a teacher must understand the importance of integrated pedagogical education programmes, and have expert knowledge from the main subject area and working knowledge in other areas (Corlu, R. Capraro, & M. Capraro, 2014; Williams, 2011).

Implementation of STEM disciplines is required depending on the level of development of the innovative educational environment of the educational institution. Under the innovative educational environment of the university, we will understand organisational, educational, methodological, technological, and informational resources, the purpose of which is to create conditions for the development of digital STEM competences of teachers.

The purpose of this article is to consider the problem of the influence of the innovative educational environment of the university on the development of digital STEM competences in the process of training teachers of the new formation.

Implementation of STEM Education at Ternopil Volodymyr Hnatiuk National Pedagogical University

The policy of coordination between school and university will improve the quality of pedagogical education at the initial stages of the implementation of STEM education. Such coordination activity can be carried out in two directions: programmes for training of future teachers and teachers' qualification upgrading. Teacher training programmes developed in tandem with school curricula will facilitate the teachers' acquisition of the necessary knowledge and experience in the educational environment of a modern school where the principles of STEM education are implemented (Sanders, 2009).

The implementation of the principles of STEM education at Ternopil Volodymyr Hnatiuk National Pedagogical University succeeded in providing:

- integration of the best STEM educational practices of domestic and foreign experience;
- development of new teaching materials (interdisciplinary programmes) in educational institutions; and
- encouragement of students of the pedagogical university to study STEM subjects.

The STEM Centre, which is the basis of the University's innovative educational environment, has been operating in Ternopil Volodymyr Hnatiuk National Pedagogical University – at the Faculty of Physics and Mathematics – for three years. The scientific and technical activity of STEM Centre is carried out with the participation of scientific and pedagogical staff of the Department of Computer Science and Teaching Techniques. Teachers of the Department provide educational services in the field of STEM to students and teachers.

The aim of the STEM Centre as an innovative educational environment of the University is to create organisational and pedagogical conditions for advanced scientific and technical youth education in accordance with the priority directions for science and technology development, and to form the competences that determine the competitiveness of the individual in the labour market. The profile of the educational activities of the STEM Centre of the University determines the following areas of STEM education: IT, robotics, virtual reality, Internet of things, 3D modelling, and 3D printing.

This profile is provided by the availability of the appropriate equipment: LEGO construction toys, robotic systems, models, measuring complexes and sensors, 3D printers, computers, digital projectors, projection screens, interactive whiteboards, document cameras, etc. High-tech equipment helps students in designing and researching, modelling various processes and phenomena, and mastering new transdisciplinary knowledge consciously and qualitatively.

The activities of the STEM Centre are based on pilot-oriented project-based learning aimed at in-depth study of specialised disciplines and the acquisition of digital STEM competences required for experimental, design, and inventive activities.

The STEM Centre activity forms STEM competence of students, and they acquire knowledge in many disciplines and learn skills in using interdisciplinary approaches to solve real-life problems (Balyk, Barna, Shmyger, & Oleksiuk, 2018).

The transition to the competence model of STEM education at Ternopil Volodymyr Hnatiuk National Pedagogical University is based on the application of the following methodological approaches:

- shifting in emphasis in educational activities from narrow-subject to common didactics;
- setting a new goal in the pedagogical process;
- updating the structure and content of curricula, courses, and specialised courses;
- introducing competence-oriented forms and teaching methods;
- assessing learning outcomes in terms of competences;
- introducing innovative teaching technologies (case-study technologies, interactive methods of group training, problem-oriented techniques for developing critical and system thinking, etc.); and
- creating pedagogical conditions for gaining experience of project activity and start-ups development.

The STEM Centre provides education based on the principles of differentiated and individual approaches to learning, taking into account age, individual abilities, interests, likes, abilities, and health status of children and young people, using different organisational forms of work.

A special form of pervasive STEM education are integrated lessons aimed at establishing inter-subject relationships and contributing to the formation of a holistic, systematic outlook. Integrated classes are conducted by combining similar topics of several educational subjects or forming individual ones. The basis of the effectiveness of such classes is a clear definition of their purpose and plan.

The use of the leading principle of STEM education, that is, integration (interdisciplinary, transdisciplinary) makes it possible to modernise methodological foundations, content, and volume of educational material and to apply modern technologies during education process in order to form competences on a qualitatively new level.

In order to involve students in practical activities at the STEM Centre, organisational forms and teaching methods, as well as methods of educational interaction were expanded. For better acquisition of learning material and formation of digital STEM competences, we conduct tours, quests, contests, festivals, hackathons, trainings, and seminars.

In addition to traditional intellectual events (contests, tournaments), the STEM Centre plans to conduct scientific-educational events, STEM weeks, scientific picnics, festivals on robotics, and maker fairs. The STEM Centre also organises and holds events for vocational guidance (trainings, excursions) of students concerning a conscious choice of future profession, taking into account the regional characteristics of the labour market. Examples are: STEM-creaton regional festival, STEM-spring all-Ukrainian festival, Day of Science, Visiting TNPU, Class Idea festival of startups, the all-Ukrainian festival of innovations, winter and summer STEM-schools.

An effective tool for the development of digital STEM competences is a project activity that changes the emphasis of learning activities. The acquisition of knowledge, skills, and abilities that – in the global information environment – are losing their relevance cannot be a goal in itself, while the research skills and practical experience gained in the process of project activity will promote acceleration of adaptation of young people to a changing social and economic life.

Implementation of educational projects involves an integrated research and creative activity of students, aimed at obtaining independent results under the teacher guidance. In the process of studying various courses and specialised courses, students develop training projects based on the system of integrated tasks simulated from real life situations.

The teacher manages such activities, encourages students to search; he helps in determining the goals and objectives of the project, advisory methods or techniques of the research, and in information seeking to solve certain educational and cognitive tasks. Students themselves choose the form of presentation and defend the received results. Evaluation of the project activity is carried out individually.

During the execution of educational projects, a number of different levels of didactic, educational, and developmental tasks are solved: new knowledge, abilities, and skills are acquired; motivation and cognitive interests are developed; the abilities to independently navigate the information space, express one's own judgments, and identify competence are formed. The design work contributes to the formation of STEM competences (Shmyger & Balyk, 2017), and allows passing the technological algorithm from the problem's discovery, or the origin of the idea, to the creation of a commercial product – a startup, as well as learning to present it to potential investors. Ultimately, this will contribute to changing the value priorities and ideological position of youth in the direction of the formation of responsible and socially active social behaviour.

In the educational process, the teachers of the Department of Computer Science and Teaching Techniques of Ternopil Volodymyr Hnatiuk National Pedagogical University test different types of projects: project-task, project-discipline, and project-start-up. Here are some examples of the projects:

- study with pleasure,
- STEM projects,
- technologies of a successful personality development,
- make the city better,
- development of the project and social management system,
- development of media resources for the creation of an open co-learning centre for the promotion of the ideas of the Ukrainian Charter of the Free Person,
- development of innovative educational projects based on the concept of the New Ukrainian School, and
- innovative approaches to the use of ICT and competence education in the conditions of the New Ukrainian School.

Let us place greater focus on the implementation of the educational project "Development of innovative educational projects based on the principles of the New Ukrainian school," which started in 2017. As a result of it, more than two hundred portfolios of integrated educational projects were developed and performed by undergraduates of all specialties of the University for primary and secondary school teachers.

The current vector of the innovative educational environment of the University is the organisation of the educational process as an integral part of the entire educational process and orientation, primarily, on universal human values. One of such innovative projects in the social sphere, which implements the innovative function of the University for the creation of new social and humanitarian practices, was the project to popularise the ideas of the Ukrainian Charter of the Free Person.

Future teachers created methodological support with media to promote ten Charter novels and their practical use with education and training aim in educational institutions, as well as for public community activities in Ukraine.

Research Results

In our opinion, the key to the development of digital STEM competences was the impact of the University's innovative educational environment and the activities of the STEM Centre. In 2017/2018, a poll was conducted to determine the factors of the University's innovative educational environment that have the greatest impact on the development of digital STEM competences for preservice teachers.

The survey involved 138 students of the third year of the Faculty of Physics and Mathematics and the Faculty of Chemistry and Biology. The questionnaire offered to evaluate the components of the innovative educational environment of the university on a 5-point scale and to determine the importance of the development of each component on a 3-point scale: 1 – low, 2 – medium, and 3 – high.

Let us consider the results of the survey conducted concerning the importance of developing the hardware, organisational, methodological, and software components of the university's innovative educational environment for the development of digital STEM competences of students at Ternopil Volodymyr Hnatiuk National Pedagogical University (Figures 1–4).

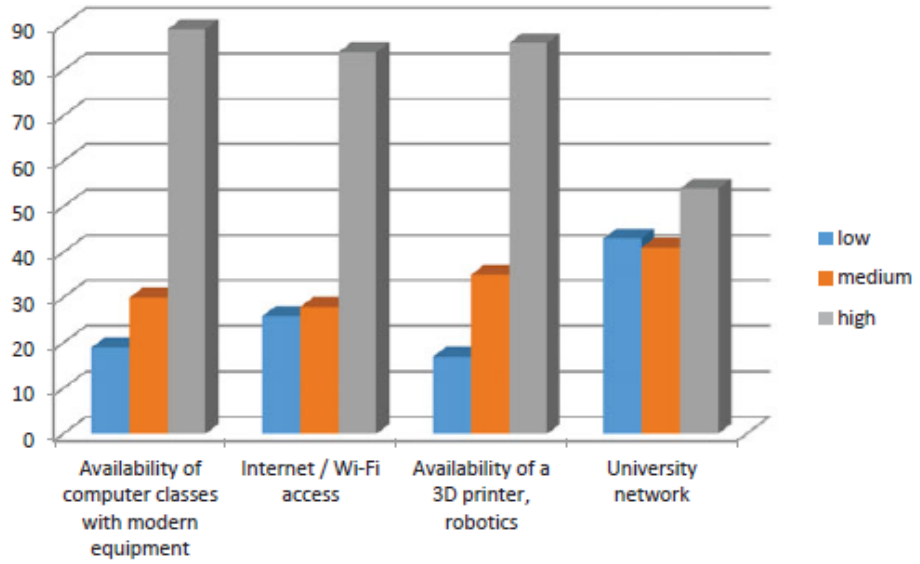

Figure 1. Results of the study of the importance of the hardware component of the university's innovative educational environment in the context of the development of digital STEM competences.

Source: Own work.

Concerning the hardware component, such indicators as availability of a 3D printer, robotics, and other equipment of the STEM Centre (65%), modern computer classes (61%), high-speed Internet (62%), and developed university computer network (39%) are the most significant (the importance of the component on a 3-point scale is high) for development of the digital STEM competences of students. A small percentage of university network component can be explained by the fact that there is a sufficient number of students possessing gadgets with Internet access.

In recent years, the University has been actively introducing non-formal education (training sessions, workshops, seminars, webinars, round tables, conferences, contests, internships). Therefore, 63% of students (the importance of development of a component on a 3-point scale is high) noted it as a factor that

greatly influenced the development of their digital STEM competences. It can be summarised that in the framework of the innovative educational environment of the university, formal and non-formal education of future teachers complement each other, compensating for disadvantages of these types of education.

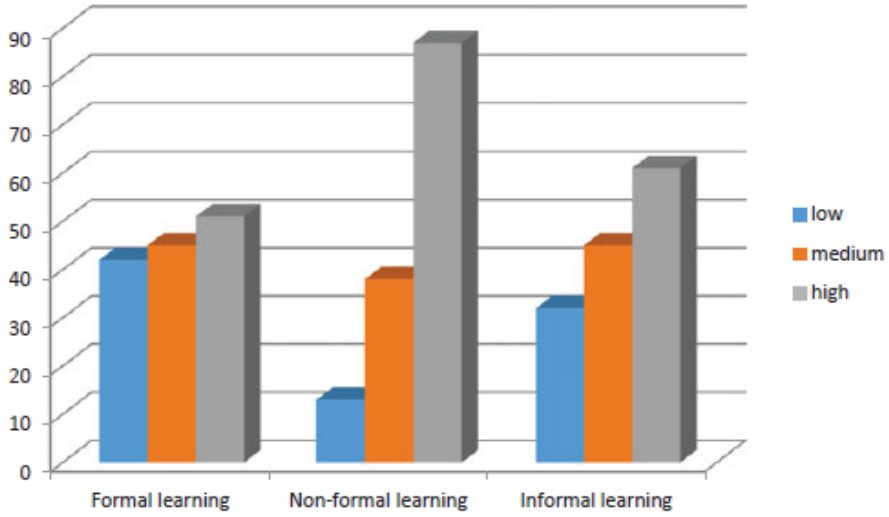

Figure 2. Results of the study of the importance of the organisational component of the university's innovative educational environment in the context of the development of digital STEM competences.

Source: Own work.

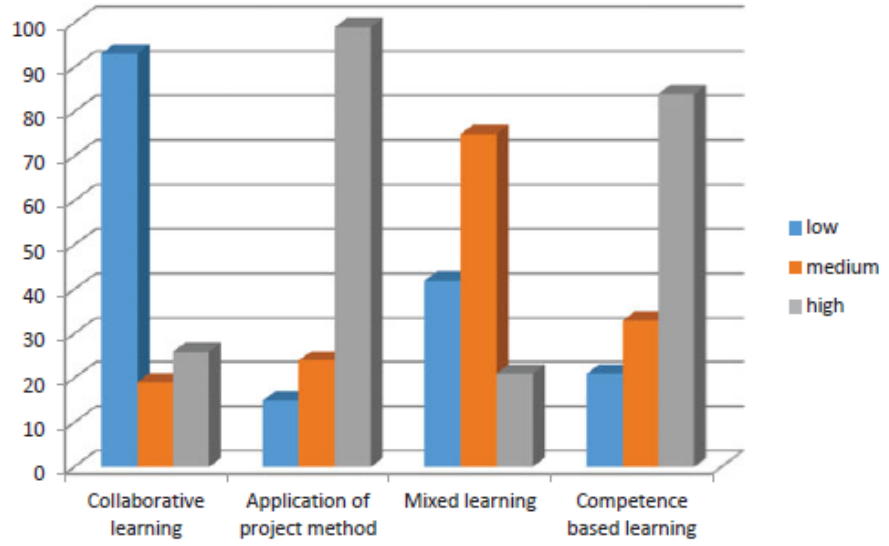

Figure 3. Results of the study of the importance of the methodical component of the university's innovative educational environment in the context of the development of digital STEM competences.

Source: Own work.

Among the teaching methods, students of Ternopil Volodymyr Hnatiuk National Pedagogical University have allocated project-based learning (72%) and competence-based learning (61%) as important ones (the importance of development of the component on a 3-point scale is high). Despite the high rates of project-based learning and competence-based learning, students (67%) still do not accept collaborative learning (the importance of development of the component on a 3-point scale is low).

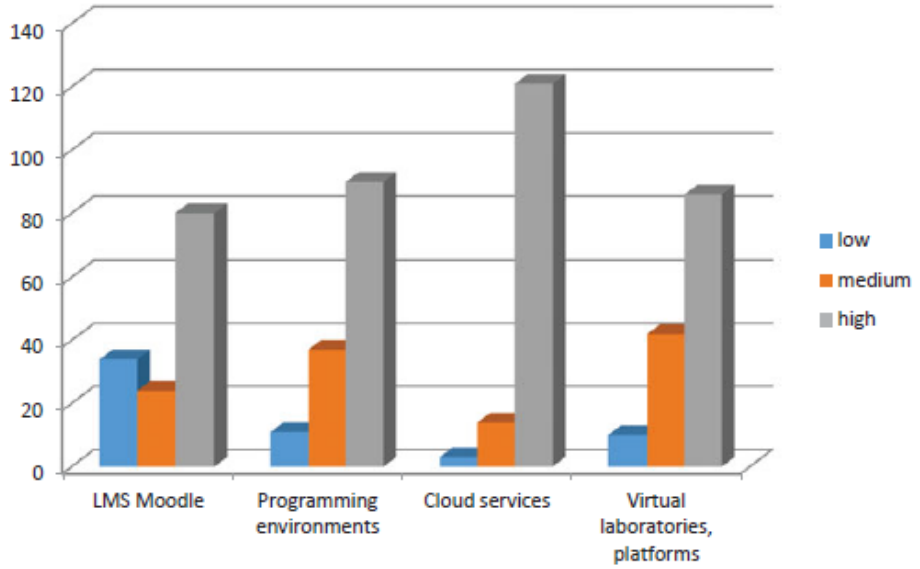

Figure 4. Results of the study of the importance of the programming component of the university's innovative educational environment in the context of the development of digital STEM competences.

Source: Own work.

Cloud computing (87%), programming environments (65%), virtual laboratories and platforms (62%) proved to be the most important concerning the software component of the programme (the importance of development of the component on a 3-point scale is high) for the development of digital STEM competences of students.

Modernisation of the software component enabled combining traditional and cloud-based learning tools, integrating cloud services (Google, Microsoft) into the IT infrastructure of the University, and organising training courses based on cloud platforms and cloud services.

In the learning process, we use cloud services for the development of creativity (Table 1), leadership and responsibility (Table 2), and problem solving (Table 3), but also for strengthening collaboration and team work (Table 4), and the development of effective communication (Table 5).

Digital Tools for STEM Competences Development

Table 1.
Digital tools for development of creativity

Creativity – an innovative mindset	
Easely	creating posters and infographics
Prezi	online presentation tool
Dumpr	creating photo collages by templates
BannerSnack	creating banners
EnjoyPic	creating combined images with photos and applying animations
Photosynth	creating three-dimensional modelling of photo panoramas

Source: Own work.

Table 2.
Digital tools for development of leadership and responsibility

Leadership and responsibility – initiative and awareness of personal responsibility	
Google Apps	organising collective work by creating a joint document or presentation
Facebook	moderating a thematic group in a social network, communicating with readers
Trello	effective management of own tasks and tasks of members of a team (group, project)
Blog	keeping an online diary, covering the news and own vision, and sharing thoughts on a topic

Source: Own work.

Table 3.
Digital tools to develop problem solving

Problem solving – will, awareness of the causes and consequences	
Bubells, Mind42	creating a map of knowledge with all possible options for solving the problem, thinking out the possible results of each solution
OneNote	writing down problems and tasks, adding decision ideas, and noting solved problems and tasks
Forum2x2	organising forums for communication and discussion
WebTalk, Skype	asking for help, talking and consulting with others

Source: Own work.

Table 4.
Digital tools for enhancing cooperation and teamwork

Cooperation and teamwork – abilities to plan activities collectively, work together, distribute roles and responsibilities, and focus on results	
Google Docs	creating and editing documents, spreadsheets, or presentations together; commenting and discussing created materials
Google Drive	saving documents, programmes, music, videos, photos in a shared repository; giving access to files to other users
Padlet	sharing reviews or suggestions on a shared board; printing text, drawing, embedding files, using full board for further work
Google groups	organising work with groups
Dreams Board	creating an informational virtual board (images, stickers, text)
Google calendar	creating a joint on-line organiser with a schedule of events, promptly updating information, conducting group correspondence on a certain topic

Source: Own work.

Table 5.
Digital tools for the development of effective communication

Effective communication – expressing and arguing opinion, possessing rhetorical skills, achieving communicative goals	
Skype, Viber	communicating and solving problems with people anywhere, regardless of their location; teaching and learning through online communication
Buzzumi, Speakplace	organising video communication, conferences, webinars, video interviews; creating and organising audio conferences
Google Forms	creating questionnaires and conducting online surveys to determine the needs or personal opinions of people; analysing the results of the surveys in the charts
Gmail, Outlook	communicating competently by e-mail, taking into account the ethics of communication; organising the contacts of people

Source: Own work.

Using the abovementioned cloud services made it possible for students to aggregate computing resources, increase the flexibility of their use, and create scalable repositories based on cloud computing.

Conclusions

The basis of the innovative educational environment at Ternopil Volodymyr Hnatiuk National Pedagogical University is the modern STEM Centre. Transition to STEM education competence model in Ternopil Volodymyr Hnatiuk National Pedagogical University is based primarily on creating conditions for teachers to gain experience of project activities.

The study revealed the factors that most contributed to the development of digital STEM competences in the pedagogical university: the availability of high-tech equipment STEM Centre; modern computer labs and high-speed Internet; advanced university computer network; virtual laboratories and platforms; programming environments and various cloud services; project-based learning and competence-based learning.

The results of the survey will enhance the effectiveness of the learning process and further development of teachers' digital STEM competences.

The prospect for further research is to develop educational strategies for the implementation of STEM education in the process of teachers' qualifications upgrading.

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Wpływ uniwersyteckiego innowacyjnego środowiska edukacyjnego na rozwój cyfrowych kompetencji STEM

Streszczenie

Artykuł dotyczy kwestii wpływu uniwersyteckiego innowacyjnego środowiska edukacyjnego na rozwijanie cyfrowych kompetencji STEM (kompetencji cyfrowych z zakresu nauki, technologii, inżynierii i matematyki) w procesie szkolenia nowego pokolenia nauczycieli. Określono, że innowacyjne środowisko edukacyjne uniwersytetu składa się z zasobów organizacyjnych, edukacyjnych, metodologicznych, technologicznych i informacyjnych. Celem takiego środowiska jest rozwój cyfrowych kompetencji STEM u nauczycieli. Zanalizowano główne aspekty wprowadzenia i rozwoju kompetencji STEM w edukacji w różnych krajach świata. Zwrócono szczególną uwagę na funkcjonowanie centrum STEM, które jest podstawą innowacyjnego środowiska edukacyjnego uniwersytetu pedagogicznego. Dokonano podsumowania praktycznego doświadczenia we wprowadzaniu edukacji o profilu naukowym, technicznym, inżynieryjnym i matematycznym (STEM) na Narodowym Uniwersytecie Pedagogicznym im. Wołodymyra Hnatiuka w Tarnopolu na Ukrainie. Zbadano szczególne aspekty wpływu innowacyjnego środowiska edukacyjnego Uniwersytetu na rozwój cyfrowych kompetencji STEM.

Słowa kluczowe: edukacja STEM, cyfrowe kompetencje STEM, innowacyjne środowisko edukacyjne, uczenie się metodą projektów, badania

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Влияние инновационной образовательной среды университета на развитие STEM компетенций в области цифровых технологий

Аннотация

В статье рассматривается проблема влияния инновационной образовательной среды университета на развитие цифровых компетенций STEM в процессе подготовки преподавателей для нового образования. Определено, что инновационная образовательная среда университета состоит из организационных, образовательных, методических, технологических и информационных ресурсов, целью которых является создание условий для развития цифровых STEM компетенций преподавателей. Анализируются основные аспекты внедрения и развития обучения STEM в разных странах мира. Особое внимание уделяется функционированию центра

STEM, который является основой инновационной образовательной среды педагогического университета. Обобщен практический опыт внедрения STEM-образования в Тернопольском национальном педагогическом университете имени В. Н. Гнатюка. Рассмотрены особенности влияния инновационной образовательной среды университета на развитие цифровых компетенций STEM.

Ключевые слова: STEM образование, цифровые STEM компетенции, инновационная образовательная среда, проектное обучение, исследования

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Influencia de entornos educativos universitarios innovadores en el desarrollo de competencias digitales innovadoras

Resumen

El artículo aborda la influencia de entornos educativos universitarios innovadores en el desarrollo de competencias digitales STEM en la formación del profesorado. Se determina que un entorno educativo innovador en la universidad consiste en recursos organizativos, educativos, metodológicos, tecnológicos e informativos, cuyo objetivo es crear un contexto apropiado para el desarrollo de las competencias digitales de los docentes. Se analizan los principales aspectos de la implementación y el desarrollo de la educación STEM en diferentes países del mundo. Se presta especial atención al funcionamiento del centro STEM, que es la base del entorno educativo innovador de la universidad pedagógica. Además, se resume la experiencia llevada a cabo en Volodymyr Hnatiuk Ternopil National Pedagogical University con competencias STEM. Se exploran las peculiaridades de la influencia del entorno educativo innovador de la universidad en el desarrollo de las competencias STEM.

Palabras clave: educación STEM, competencias digitales STEM, entorno educativo innovador, aprendizaje basado en proyectos, investigación